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BULLETIN No. 30

Fourth Edition, MARCH, 1923

An Investigation of Pipe Corrosion

Showing service records of iron, steel and brass pipe used for hot and cold water supply lines in 129 Pittsburgh Apartment Buildings

By THOMAS F. PAYNE

Sanitary Engineer, formerly Instructor in Plumbing, Carnegie Institute of Technology and Superintendent Specialty Department, Standard Sanitary Manufacturing Company

FOREWORD

This report is published as being of general interest to architects, engineers and builders, not only in Pittsburgh where the investigation was conducted, but in many other important cities where the domestic water supply is of the same general character, being taken from nearby streams or lakes. This similarity exists in practically all the larger cities of the Atlantic Coast States, in the South, Southwest, Middle West and even in the Mountain and Pacific Coast States.

Analyses of tap water in Pittsburgh and a few other cities are given on page 19 for the guidance of those who wish to make a comparison with tap water in their own localities.

Since the publication of the first edition of this bulletin, we have been asked if there is any explanation of the fact that iron pipe does not give up its rust as easily as steel, as mentioned under heading "Rusty Water" on page 7. We frankly confess that we do not know, any more than we know why cast iron, zinc, brass and other metals form rust or oxides of a more or less adhesive, impervious character. As in these cases, the mere knowledge of the fact is of paramount value to the practical man.

It is possible that the network of infinitesimal, non-corrodible slag fibers contained in wrought iron (but not in steel) tend to enmesh the slowly forming rust, preventing it from being loosened from the iron by the flow of water.

A. M. BYERS COMPANY.

PITTSBURGH, OCTOBER, 1919.

PURPOSE OF THE INVESTIGATION

The rapid rusting of water pipes, especially those carrying hot water, in the Pittsburgh District, has frequently been commented on in the daily press and the subject was, in the beginning of 1917, taken up for discussion and investigation by the Pittsburgh Board of Trade. In this respect, Pittsburgh is no different from many other large cities in the United States, where similar complaints are common. So far, no systematic investigation had, however, been made by a house-to-house canvass of buildings to ascertain the difference in life between the different kinds of pipe. The A. M. Byers Company therefore arranged for such an investigation with a view to ascertaining the pertinent facts which might aid property owners in meeting the rust difficulty in the most efficient manner.

(Whenever "Iron" or "Steel" Pipe is referred to in this Report, *Galvanized* Pipe is meant).

BOARD OF TRADE INVESTIGATION

In the local agitation which preceded the Board of Trade investigation, it was charged that chemicals which destroyed the pipes were used at the filtration plants. A thorough investigation of the filtration system was therefore made by a "Committee on City Water," appointed by the Pittsburgh Board of Trade, and a report was rendered embodying a discussion prepared by Chas. A. Finley, Managing Engineer, Bureau of Water, which clearly showed that no chemicals were used in the plants which could in any way be responsible for the trouble.

The report presented to the Board of Trade contains the following conclusions:

> "The fact that there is more or less inferior pipe in service which does not meet requirements is to be deplored, but should not be charged to the character of the water, nor should the preservation of this piping be accomplished by means of costly, highly complicated and objectionable treatments, at the public expense."

DIFFERENCE IN RUST RESISTANCE OF IRON, STEEL AND BRASS

The corrosive effects of Pittsburgh water have always been recognized, even long before the filtration plant was completed. This is borne out by the fact that brass pipe has here, as elsewhere, been used to a considerable extent instead of lead or wrought iron, for both hot and cold water supply. This custom, to judge by the evidence collected, seems to have little in its favor, being in most cases decidedly expensive, as the excessively high cost of this material has proved out of all proportion to its life in service. **The failure of brass pipe was, in fact, made the subject of special mention and comment in the Report of the "Committee on City Water."**

Men interested in the Board of Trade inquiry were of the impression that galvanized hot water pipes of iron and steel only lasted from four to five years, and that there apparently was no difference between the two metals. They frankly admitted, however, that this was only an impression and that they would like to obtain more definite data on the subject.

Manufacturers of steel pipe energetically opposed the idea that there was any difference in the lasting quality of iron and steel pipe respectively, and put the whole blame on the service conditions, contending that where conditions were equal, one kind of pipe would last as long as another.

CLASS OF BUILDINGS INVESTIGATED

After several unsuccessful attempts to obtain accurate data from private residences and other buildings, it appeared for many reasons that apartment buildings offered the best field for investigation. First of all, the investigation could be made to cover the entire field and still be held within reasonable limits, as the number of apartment buildings in Pittsburgh is comparatively limited. Thus, while the 125 or more apartment buildings recorded herein do not include all the apartment buildings in Pittsburgh, they do represent the majority.

Buildings erected within the last few years have been omitted, as it was impossible to form any accurate estimate of the future life of the piping; also buildings where accurate data could not be obtained as to amount of repairs made in previous years, kind of pipe originally used, age of building, etc. Only in a few instances did the proprietor decline to give any information or to permit inspection of the piping. In a single case, that of a very large modern apartment building, erected in 1912 and equipped with steel pipe which was reported to be causing much trouble, the owner absolutely refused to give any information, evidently fearing the loss of prospective tenants who might be informed that the pipes in the apartments were giving out and causing inconvenience to occupants.

D'Arlington Apartments, erected 1909, equipped with brass pipe. The hot water lines are badly corroded and pitted after 8 years' service. Record No. 7, Brass Installations, page 17.

DIFFERENCE IN SERVICE CONDITIONS

It is true that conditions of service vary to a great extent, according to the size of pipe, its thickness, the quantity and temperature of water used, etc. There is even a difference in corrosive effects between piping in different parts of the same building, it being conclusively shown in hot water systems that—

1. The corrosion in hot water lines gradually decreases with the distance from the boiler.
2. The corrosion is more severe in mains or horizontal lines than in vertical lines conveying either hot or cold water.

Furthermore, there may be more corrosion in buildings in one locality than in another, due possibly to more air entering with the water into service pipes in buildings located near the filtration plants or pumping stations.

These differences, however, present no insurmountable obstacle to a fair comparison of the service given by different kinds of pipe in different buildings, and in this investigation careful note was made in every case of the various factors which might accelerate or retard corrosion, these factors all being taken into account in connection with the tabulated records.

Altogether, these records show a remarkable similarity of performance of each of the different kinds of pipe used in various buildings, so much so that the average life of iron, steel, or brass pipe respectively, in the first ten or twenty buildings investigated, coincides almost exactly with the average for the entire number of buildings investigated, leading to some exceedingly important conclusions regarding the choice of materials for plumbing pipes.

Under the most severe service conditions, in a total of over 125 buildings, genuine wrought iron pipe proved to have double the life of soft steel or "wrought pipe," and brass proved to be only slightly better than wrought iron and certainly not enough better to warrant the many times greater first cost.

The service conditions in the apartment buildings investigated were found to be identical in the following respects:

1. City water used in all.
2. Closed system used in all.
3. Ordinary gas heater and hot water boiler or storage tank used in every case, except where otherwise mentioned.
4. The temperature of hot water supplied was generally about the same, and certainly was not higher in the apartments equipped with steel pipe than in those equipped with iron pipe.
5. The one-pipe system was in most cases used for hot water.
6. All iron and steel pipe was standard weight, *galvanized,* no exceptions being known.
7. All joints were of the standard screw type, Briggs American Standard.

The possible points of difference are as follows:

1. Proximity to Pumping Station

The piping in buildings close to some pumping station is probably subject to more severe corrosion on account of the large amount of free oxygen in the water. (Note is made of cases of close proximity in the tabulations which follow.)

2. Location and Kind of Service

In making this investigation, a distinction was made between hot water mains in the basement and hot water risers. The corrosion of these parts of the system was recorded separately, so as to facilitate comparisons between the different buildings on an equal basis.

Lafayette and Cambridge Apartments, McKee Place, erected 1902, equipped with wrought iron pipe. Most of the hot water mains were replaced in 1917, after 14 years' service. Record No. 42, Wrought Iron Installations, page 16.

The Howe and Kent Apartments, erected 1907. The hot water mains are of brass and already show pitting. See records No. 16-17 on brass piping, page 18.

3. Size of Apartment House

The quantity of water flowing through pipes will, to a certain extent, influence corrosion, for the larger the quantity, the more abundant will be the amount of oxygen available for oxidation or corrosion. It might, therefore, be assumed that corrosion will vary to a great extent according to the size of the apartment building, and a record was therefore made of the number of apartments in each building. Some apartment buildings had two or three separate hot water systems, each system usually supplying a group of six individual apartments. Each of these groups was investigated and recorded separately as, for the purposes of this investigation, they must be regarded as separate and distinct buildings.

Contrary to expectation, however, it was found that the *life of the pipes was on an average no shorter in the larger buildings than in the smaller ones,* this being undoubtedly due to the fact that the sizes of the pipes are proportioned to the requirements, the largest buildings having the largest mains, which have heavier walls than smaller sizes of pipe and therefore afford a greater resistance to corrosion. In fact, the smaller sizes of pipe usually were found to be the first to give trouble in any part of a system where the conditions were otherwise equal. In addition, it should be noted that the range of sizes used was very small, namely from ¾″ to 1¼″.

St. Regis, Chesapeake, and Chamberlin Apartments erected 1908. Equipped with steel pipe. Most of the hot water mains have already been replaced. See records Nos. 17, 18 and 19, page 14.

Negley Apartments, erected 1909. Hot water mains of steel, largely replaced between 1911 and 1914. Trouble with rusty water. See record No. 1, page 13.

Kennett Apartments, erected 1902, equipped with brass pipe. Record No. 4, page 13. Typical of most apartments equipped with brass pipe, the hot water mains being badly corroded, after 10 to 15 years' service.

The Lexington, Argyle, and Drexel Apartments, erected 1909. Equipped with steel pipe. Life of hot water mains, 7 or 8 years. See records Nos. 13, 14 and 15, page 14.

Typical condition of pitted brass pipe after 10 years' service in hot water mains.

SUMMARY OF DATA

Accurate information as to the maximum life of the pipe used for hot and cold water supply, was only obtainable for that part of the hot water system consisting of the basement mains, for these were in most cases found to be rusted out and replaced within twenty years or less. In many buildings only a part of the mains had been replaced; an estimate was then made of the life of the part remaining, and the life was finally fixed as lying about midway between the shortest lived and the longest lived parts thereof. The estimates in no case cover more than a very limited range; therefore any error, wherever made, can under no circumstances amount to more than one year or two years. An examination of the column "Remarks," in the tabulations following, will make this clear. In the case of steel pipe, where any doubt existed, the estimate was purposely made high, so that no unfairness could be charged.

LIFE OF WROUGHT IRON AND STEEL PIPE

Hot Water Mains

The average life of galvanized wrought iron and steel hot water mains follows:

1. **Wrought iron, 14 years.**
2. **Steel, 7 years.**

These averages are based on the figures from 67 buildings equipped with wrought iron pipe and 28 buildings equipped with steel pipe.

That this ratio of 2 to 1 in favor of wrought iron is very conservative, is strongly indicated by the records of buildings Nos. 17, 18 and 52 in the table for wrought iron, pages 17-18. In these cases, iron pipe, after 16 and 11 years' service respectively, was replaced with steel which lasted only 2 and 4½ years respectively, giving a ratio of 4 to 1 in favor of wrought iron.

Hot Water Risers—Iron

The life of the risers is more difficult to estimate, but judging from their general condition as far as it was possible to do so, and the very small amount of repairs that had been required after 10 to 18 years' service, it is reasonable to assume that they will in most cases last three times longer than the hot water mains. If pipe one size larger than that required in ordinary practice were used, the life would probably be four times longer.

Hot Water Risers—Steel

The life of steel risers appears problematical, for none of the buildings equipped with steel pipe was over 12 years old, and most of them less than 10. It is safe to say, however, that the life of steel risers will bear about the same ratio to wrought iron risers as indicated by the life of the mains, namely, one to two in favor of wrought iron, which means that steel risers would have to be replaced some time during the useful life of the average building, probably within 20 years.

RUSTY WATER

A very important fact was unexpectedly developed during this investigation. Many complaints have been made on account of rusty water staining bath tubs, lavatories, sinks and other plumbing fixtures; also staining clothing to such an extent that no amount of subsequent washing in rust-free water would restore the original color of the fabrics.

Not a single instance of rusty water was found where wrought iron pipe was installed, even where the pipe itself was rusted out and needed replacing.

On the other hand, in practically every building where steel pipe was used, the rusty water

first appeared after three or four years' service. In several instances, filters had been installed in the belief that they would remedy the trouble. These filters were placed near the boiler in the basement, and only filtered the rust coming from the boiler and the short piece of pipe between the boiler and the filter and, therefore, only partly eliminated the trouble. The expense of installing and maintaining these filters would have been more than sufficient to pay for the extra cost of wrought iron pipe, obtaining for the occupants pipe of double the life and eliminating the rusty water trouble.

BRASS PIPE UNSATISFACTORY

Hot Water Lines

The life of brass can only be estimated, as corrosion of brass does not, as a rule, result directly in leaks, but causes the pipe to become so fragile that it breaks when a wrench is applied or when it is subjected to shocks, expansion or high water pressure. *The piping is most of the 34 apartments investigated which were piped with brass began to show signs of corrosion within 6 to 8 years and was very badly pitted after 10 to 15 years.* When repairs or alterations had to be made, the pipe would break at the threads when turned with a wrench, and keep on breaking, resulting in heavy replacement expense. The expansion of the pipe also caused it to break at the joints between the risers and the branch lines from fixtures located up through the building where the pipe is concealed in the wall, causing unusually costly repairs.

Cold Water Lines

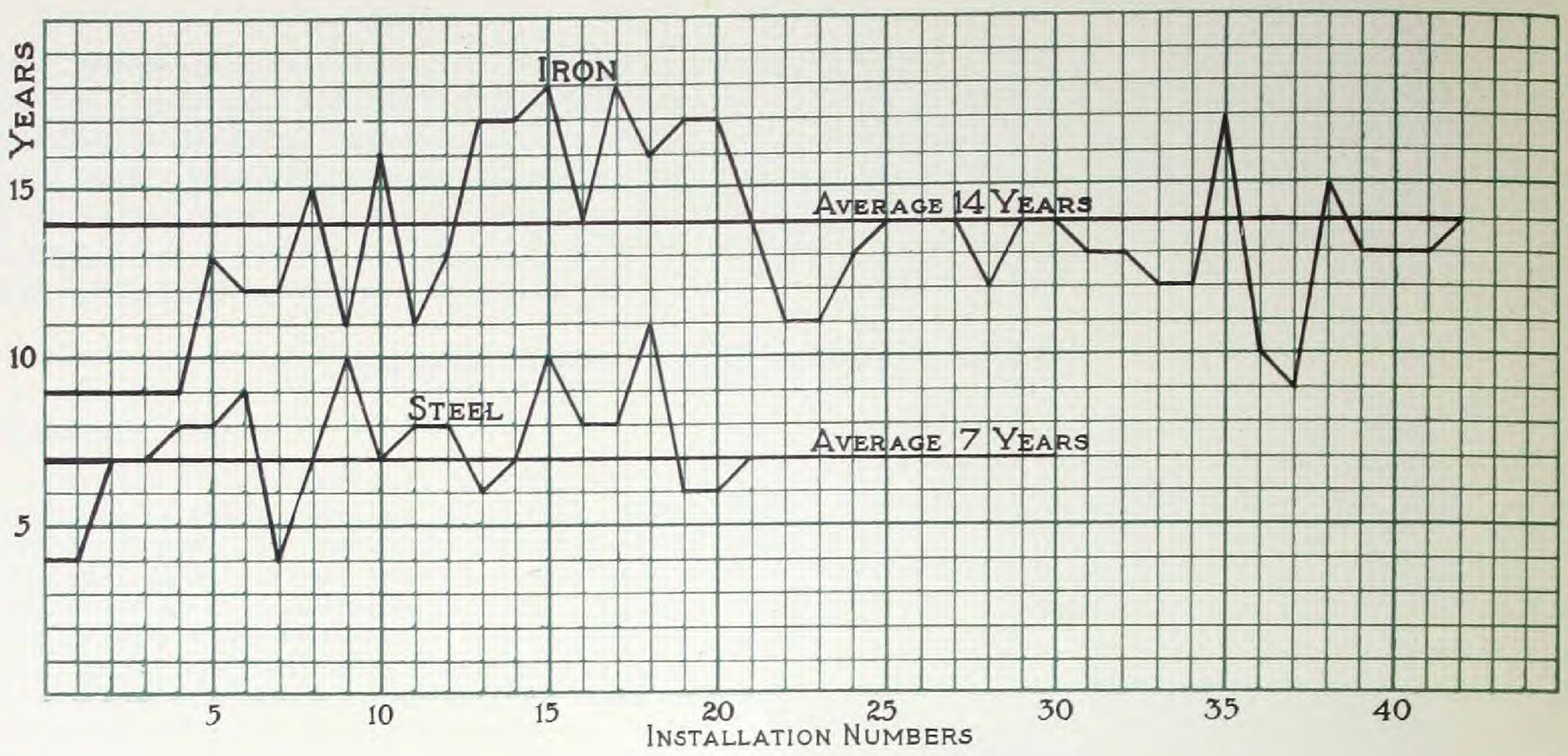
No trouble was experienced with either wrought iron or brass pipe for cold water lines, and no information could be obtained from any source to show any advantage of brass pipe over good wrought iron pipe for this service. In fact, as the screw joints on small sizes of brass pipe were frequently found in a leaky condition, necessitating repairs, wrought iron pipe seemed to have a decided advantage, both in respect to price and quality of service.

Oakland Apartments, Halket and Forbes Streets, erected in 1902, and equipped with wrought iron pipe, all of which is still in good condition, excepting the hot water mains which now needed replacement after 15 years' service. See record No. 55, Wrought Iron Installations, page 17.

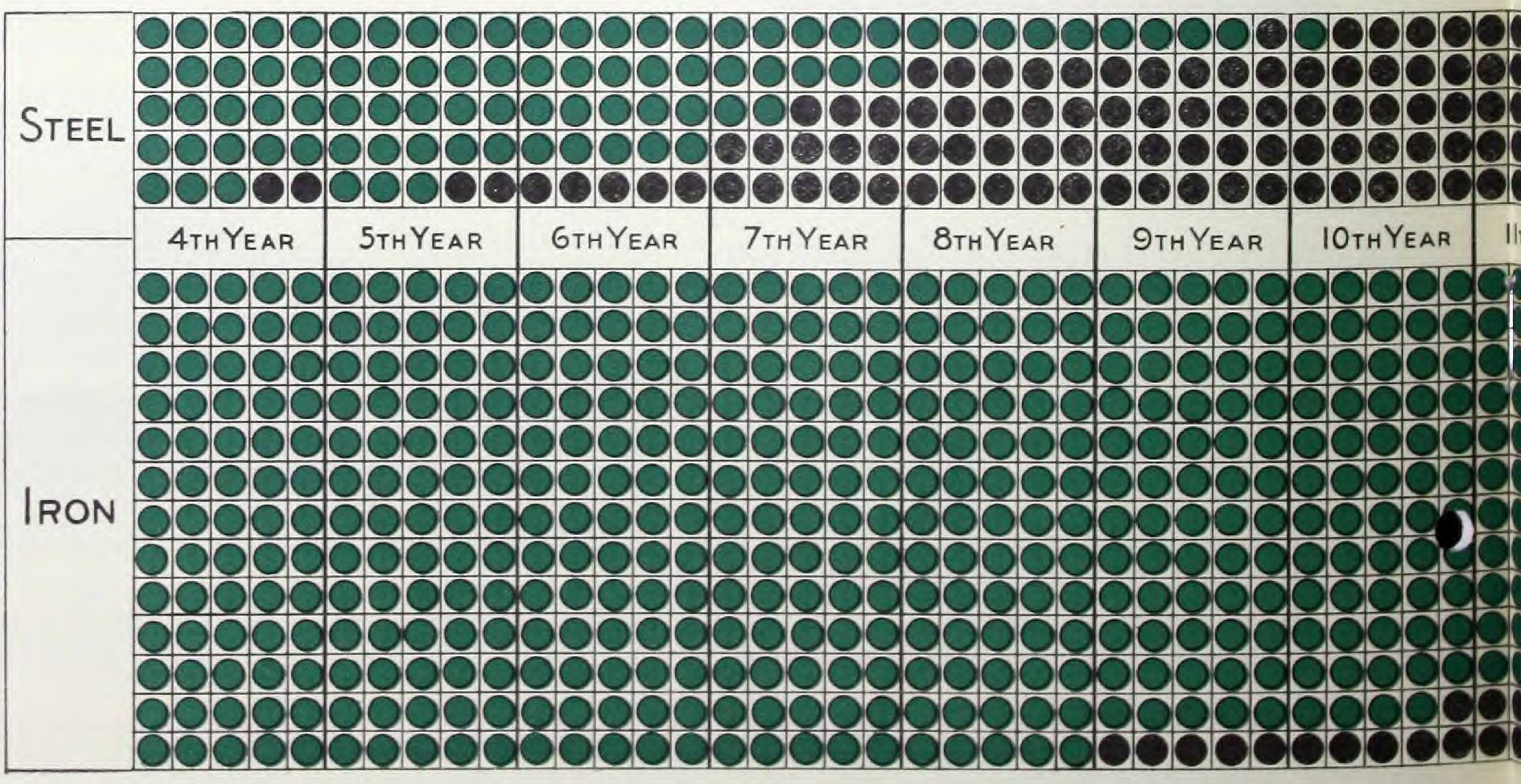
Yellow Brick Apartments, erected 1902. Equipped with wrought iron pipe. Hot water mains needing replacement after 14 years' service. See records Nos. 43 and 44, page 16.

That brass pipe years ago came into use at all for water supply undoubtedly was due to a belief that it was practically everlasting. Since this belief has not been substantiated by experience, **and since genuine wrought iron pipe has been proven to last as long as the average building** (except for hot water mains), the use of brass pipe is rapidly being abandoned by thoughtful architects and builders, for the difference in cost between the two materials is so great that wrought iron pipe could be replaced several times during the life of the building at a total cost not exceeding the first investment in the brass pipe installation, plus interest. No such replacement need, however, be looked for,

CURVE SHOWING LIFE OF IRON AND STEEL PIPE



The curve above illustrates the life of hot water *mains* (exposed basement piping) in the 90 buildings which were equipped with iron and steel pipe. The "Installation Numbers" correspond with the individual record numbers shown in tabulations on pages 13 to 17 inclusive. The hot water *risers* are subject to much less corrosion, lasting so long that no definite idea can, for some years yet, be formed as to their average life. The significance of the data lies in the *ratio of life* established between iron and steel pipe,—namely, 2 *to* 1 *in favor of genuine wrought iron.*



DOT CHART

LEGEND:—Green Dots—installations in *service.*
Black Dots—installations *replaced* on account of failure.
Years are figured from date of first or original pipe installation.
No failures occurred in the first 3 years after installation and the chart therefore starts with the 4th year.

DOT CHART

(Each dot represents one installation)

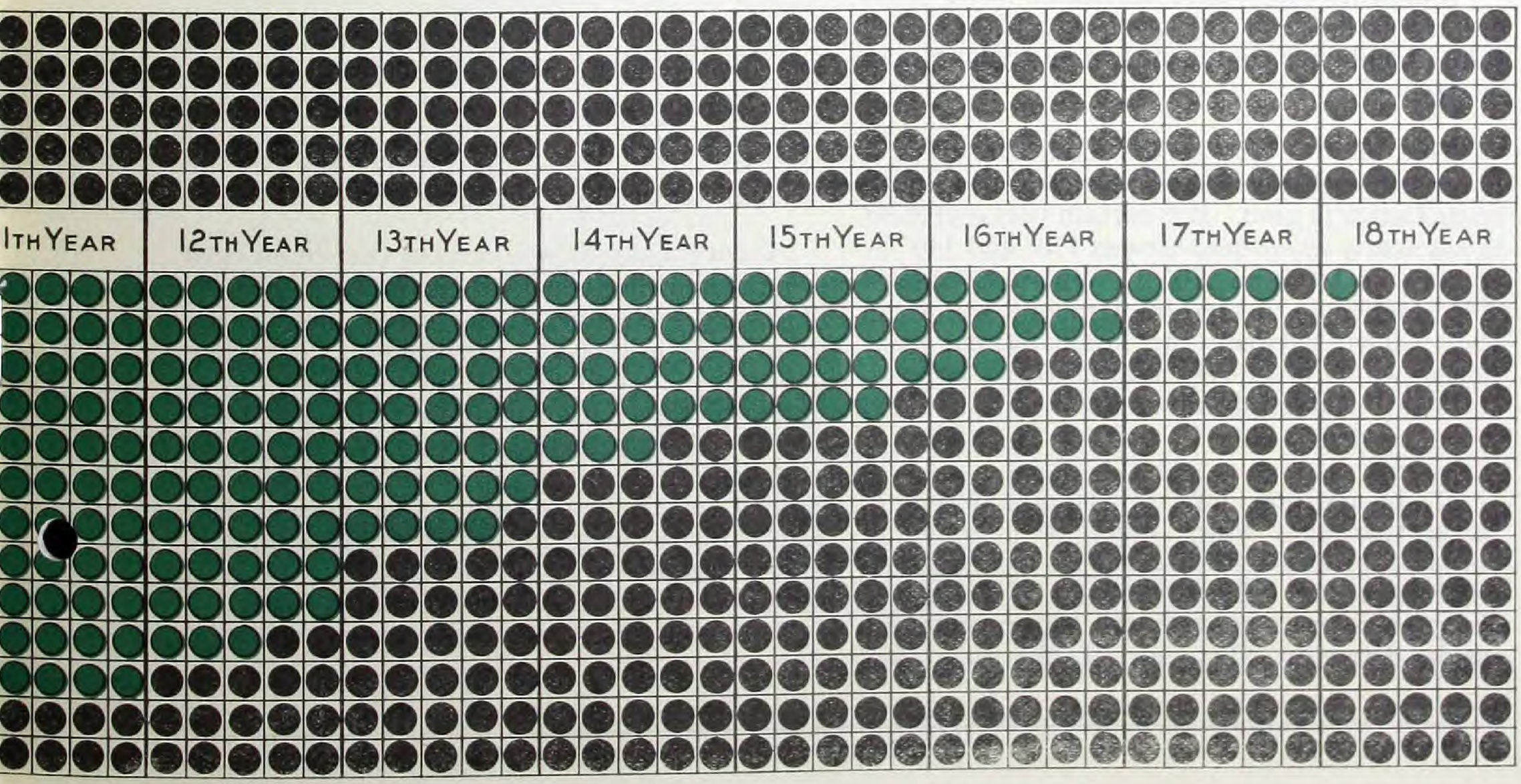
Explanatory: There are 65 dots in the wrought iron yearly division, and in the steel division 25 dots, each representing one installation. The discrepancy in these numbers is not accidental or arbitrary, for the figures represent the total number of buildings investigated, (not including those equipped with brass pipe) showing that genuine wrought iron pipe is in much more general use than steel pipe in Pittsburgh buildings. This chart graphically illustrates the fate of each installation—it shows that out of 25 *steel* installations two failed in the fourth year, three more in the sixth year, eight more in the seventh year, and so forth. Only one steel installation lasted as long as ten years, while the first five failures of wrought iron did not occur until the 9th year. Note also that 84% of the steel installations had been replaced when the first wrought iron failures occurred, and after 18 years one wrought iron installation still remained in service.

These records are for exposed Basement Mains only, none of the risers having been replaced.

By comparing the longest lived steel installations with the shortest lived iron installations, it is easy to see that there is no reliable foundation for the claim that steel pipe lasts as long as iron pipe. Unfortunately, many of the claims made for steel pipe, accompanied by a great display of apparently scientific detail, rest on an even flimsier foundation, for there is no test as certain as the test of time and actual service.

Using a similar line of reasoning, we might point to the fact that certain steel installations lasted only 4 years and certain iron installations from 16 to 18 years, outlasting steel from 4 to 5 times. Likewise we might even undertake to claim—and with considerable good evidence to back this claim—that **extra heavy iron pipe lasts longer than brass pipe.**

All of which argues for the advisability of discounting all corrosion evidence that does not rest on the law of averages, especially if it conflicts with common experience.



except in the hot water mains which are easily accessible, and where even brass has to be replaced if used. See in this connection suggestions made in the following section.

HOW TO LENGTHEN LIFE OF HOT WATER PIPING

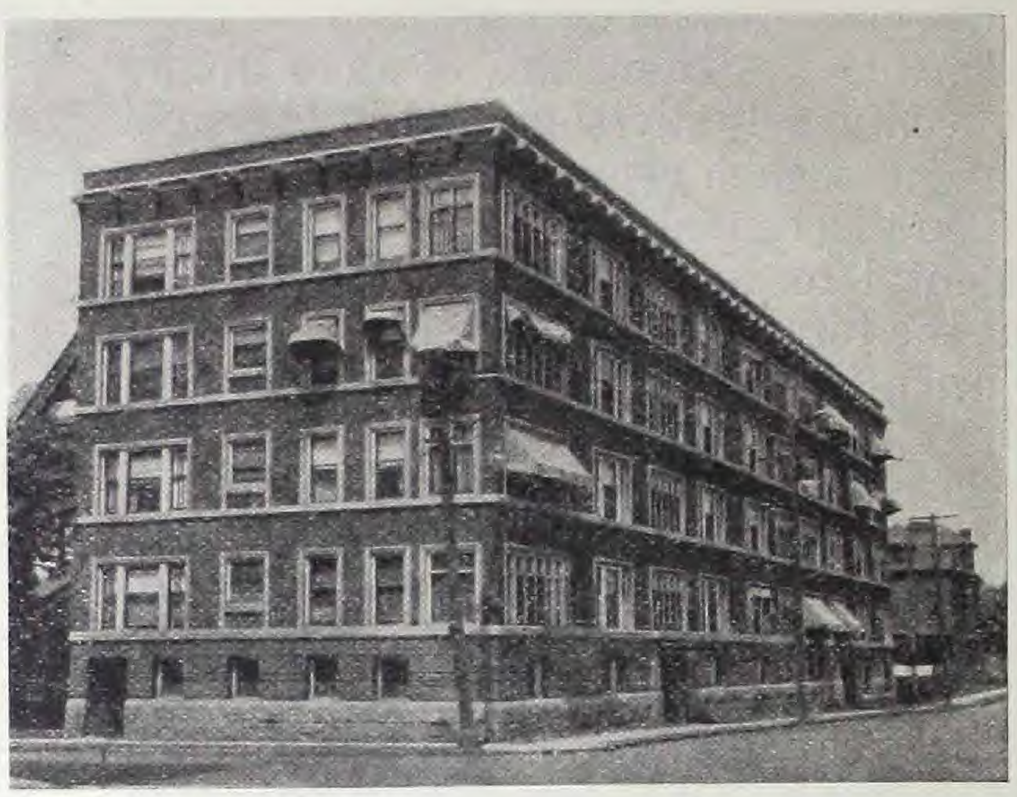
From the fact that nearly every community has trouble with corrosion of hot water lines and rusty water, the question arises how to minimize such trouble without investing, in special apparatus or materials, sums of money which are out of all proportion to the benefits derived therefrom. The life of hot water piping may, however, be lengthened by other inexpensive means.

Inasmuch as Byers genuine wrought iron pipe has an average life twice as long as that of the best steel pipe, (wrought pipe) the first precaution of a builder or architect should be to see that "genuine wrought iron pipe" is actually specified and installed where specified. Byers pipe can readily be identified by the shallow roll marks which appear every three or four feet on the pipe, reading "Byers '23," the latter figures indicating year of manufacture, being, of course, changed from year to year. The higher first cost of Byers pipe is relatively so small compared with its longer life in service as to make it short-sighted economy to allow cheaper pipe to be installed.

It appears that where automatic water heaters are used, the pipe stands up a little longer than in buildings equipped with an ordinary gas heater and tank.

This may be due to the maintenance of a lower temperature of the water where the automatic heater is used. It is certain that corrosion is not nearly as severe between 115° and 140° F. as between 140° and 170° F. Where, therefore, it is practicable to keep the temperature of the water down between the lower figures mentioned, which is an easy matter with a thermostatically controlled water heater, it is to be recommended.

If, in addition, pipe is installed which is larger than that which would be provided in standard practice, its life will be very materially lengthened. The advantages of the larger size pipe lie in its heavier wall and in its larger inside diameter. In view of the fact that



The Netherlands Apartments, Summerlea and Elwood, erected 1911, equipped with steel pipe. The hot water soon became so rusty that filters were installed in 1916. These filters, however, have not eliminated the rust from the water. See record No. 20 on page 15 and also paragraph on "Rusty Water" on page 7.

wrought iron pipe in most cases clogs up before it is actually rusted through, the larger inside diameter should be an especially strong point.

The question as to whether or not an open type of heater is practicable or preferable to a closed one, can only be solved by practical service tests. The Byers Company at the present time are not in a position to make any definite recommendations on this subject.

Theoretically, it would seem that in an open system, allowing escape of the oxygen liberated in heating the water, the corrosion would be less than in the ordinary closed system, which does not permit of such escape. In this, however, as in all other matters pertaining to corrosion, the Byers Company feel that the only safe ground is the path of experience, which as yet has remained largely unexplored. Such meager data as the Byers Company has so far been able to collect does not show up favorably for the open type heater, but this may be due to faulty design of apparatus rather than to wrong principle.

TABULATED SERVICE RECORDS

The tables following have been subdivided into three groups, the first for brass, the second for steel, and the third for iron pipe installations.

Inasmuch as it was not practicable to remove samples of the piping from a large number of buildings, the identity of iron and steel pipe was determined by obtaining filings from the pipe for the purpose of making a manganese test. Manganese, in the process of steel manufacture, has to be added to the molten metal in order to make it possible to roll and weld it into pipe, while wrought iron requires no manganese addition and therefore usually contains only a trace of this metal. In a few cases, the pipe seemed to contain too much manganese to be classified as wrought iron, and not enough to be classified as steel, and in order to be entirely fair, these cases have been left out of consideration. Where it was possible to obtain samples, the manganese test was supplemented by the crushing test, revealing the bright crystalline fracture of steel or the dull grey, fibrous fracture of wrought iron. The procedure followed in the manganese test is described on pages 18 and 19.

EXPLANATORY NOTES TO TABLES.

"Number of Apartments" In this column is indicated the number of apartments in each building which are served by a separate hot water system. It will be seen that some buildings have several hot water systems, each serving its own group of apartments.

"Hot Water Mains" Under this column is indicated the number of years of service given by the hot water mains. Where an "s" precedes this figure, it indicates that it represents an average between the longest lived and shortest lived parts of the mains.

"Still Good" Piping which is indicated as "still good," is not included in arriving at the average life, which is revealed to be 14 years for iron and 7 years for steel pipe in the hot water mains. Where it was impossible to obtain any idea of the condition of the risers, it is indicated by an interrogation mark in the column for risers.

"s" The prefix "s" before figure denoting life of pipe, indicates that it has been estimated in accordance with the rules explained under "Summary of Data," on page 7.

STEEL PIPE INSTALLATIONS

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Negley Apts. S. Negley and Elmer	18	1909	Hot water mains, largely replaced 1911-14. Rusty water.	4 yrs.	?	8 yrs. Still good
2. Berwin Apts. 3. Elmont Apts. 4. Delwood Apts. Holden Ave.	6 6 6	1907 1907 1907	Gradual replacement of hot water mains since 1912. Rusty water.	s–7 yrs.	10 yrs. Still good	10 yrs. Still good
5. Brayton Apts. 6. Crescent Apts. Negley Ave.	6 6	1907 1907	Gradual replacement of hot water mains since 1912. Some steel pipe used for replacement pitted through in one year.	s–7 yrs.	10 yrs. Still good	10 yrs. Still good
7. Darlton Apts. 8. Kingston Apts. Maryland and Elwood.	6 6	1907 1907	Instantaneous hot water heater. Entire system replaced 1915.	8 yrs.	8 yrs.	Still good

STEEL PIPE INSTALLATIONS (Continued)

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
9. Ellsworth Apts. 5806 Ellsworth Ave.	12	1908	Hot water mains in basement need replacement. Counted about 36 leaks.	9 yrs.	9 yrs. Still good	9 yrs. Still good
10. Belvedere Apts. 5523 Ellsworth Ave.	18	1910	Very large amount of trouble with rusty water. Replaced basement mains in 1914 and hot water tank in 1916 with brass and copper respectively. Still have trouble with rusty water. Replacing steel risers with iron risers.	4 yrs.	7 yrs.	7 yrs. Still good
11. Fellabaum Apts. 218-22 Beatty St.	8	1910	Basement hot water mains need replacement. Badly pitted. Rusty water.	7 yrs.	7 yrs. Still good	7 yrs. Still good
12. Darlington Apts. McKee Place	6	1907	Mixed installation of iron and steel, iron appears to be in good condition, steel rusted out.	10 yrs.	10 yrs. Still good	10 yrs. Still good
13. Drexel Apts. Penn near Homewood.	6	1909	Hot water mains and 1 riser replaced winter 1916-17.	7 yrs.	Small repair after 7 yrs.	8 yrs. Still good
14. Argyle Apts. Penn near Homewood.	6	1909	Part of hot water mains in basement replaced 1915.	s–8 yrs.	8 yrs. Still good	8 yrs. Still good
15. Lexington Apts. Penn and Lexington.	6	1909	Part of hot water mains replaced in basement 1916.	s–8 yrs.	8 yrs. Still good	8 yrs. Still good
16. Wm Pitt Apts. S. Negley and Elmer.	12	1911	Hot water mains badly corroded. Installed filter 1915 to eliminate rust, but did not accomplish purpose.	Filters 6 yrs. Still good	6 yrs. Still good	6 yrs. Still good
17. St. Regis Apts. Maryland and Howe.	18	1908	Cold water pipes too small and replaced in 1915. Hot water mains replaced 1915, account rust.	7 yrs.	7 yrs. Still good	See remarks
18-19. Chesapeake and Chamberlin Apts. Maryland and Howe.	12	1908	Gradually replacing hot water mains in basement.	s–10 yrs.	10 yrs. Still good	10 yrs. Still good
20. Netherlands Apts. Summerlea and Elwood.	20	1911	Filters installed 1916 to eliminate rusty water, but did not do so. Hot water mains partly replaced, and 1 riser entirely replaced.	s–8 yrs.	See Remarks	6 yrs. Still good
21. Gerber Apts. 724 S. Negley	6	1912	Rusty water. Some repairs made in 1916. Mains entirely replaced 1918.	6 yrs.	6 yrs. Still good	6 yrs. Still good
22. Everett Apts. Ellsworth and Bellefonte.	12	1906	Hot water mains showing some corrosion at joints. Water kept not higher than 130° which is much below average.	11 yrs. Still good	11 yrs. Still good	11 yrs. Still good
23. Ruberta Apts. Termon Ave.	6	1911	Hot water mains badly corroded and leaking.	6 yrs.	6 yrs. Still good	6 yrs. Still good
24. Henrietta Apts. Termon Ave.	6	1911	Mixed installation of iron and steel. Iron pipe next to boiler in good condition. Steel pipe rusted out.	6 yrs.		
25. 706 Summerlea St.	6	1910	Hot water mains pitted through and in bad condition. Need replacement.	7 yrs.	7 yrs. Still good	7 yrs. Still good
26-28. Pennwood Apts. 5736-48 Kentucky Ave. (13 units).	6	1910	Hot water mains rusted out and replaced 1915.	5 yrs.	7 yrs. Still good	7 yrs. Still good

WROUGHT IRON INSTALLATIONS

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Englewood Apts. Forbes St.	6	1909	A few small repairs required on hot water mains in basement since 1915.	s–9 yrs.	8 yrs. Still good	Good after 8 yrs.
2. Lynwood Apts. Forbes St.	6	1909	A few small repairs required to hot water mains since 1915.	s–9 yrs.	8 yrs. Still good	8 yrs. Still good
3. Hollywood Apts. Forbes St.	6	1909	A few small repairs after 6-8 years.	s–9 yrs.	8 yrs. Still good	8 yrs. Still good
4. Maplewood Apts. Forbes St.	6	1909	A few small repairs after 6-8 years.	s–9 yrs.	8 yrs. Still good	8 yrs. Still good
5. Summerlea and Elwood Apts. Cor. Summerlea and Elwood	18	1902	Hot water main replaced 1915.	13 yrs.	15 yrs. Still good	15 yrs. Still good
6-7. Luela and Earle Apts. (2 units). 5433 Elmer	6	1905	Hot water main about ⅔ part replaced 1916-17.	12 yrs.	12 yrs. Still good	12 yrs. Still good
8-9. Elmer Apts. No. 1 and 2. (2) Cor. Elmer and Bellefonte	6	1905	Over half of hot water main replaced 1916-17.	12 yrs.	12 yrs. Still good	12 yrs. Still good
10-12. Lennox Apts. (3 units) 223-31 Mathilda	6	1902	Some of basement mains and 1 riser up to 2d floor replaced 1915. There is a total of 12 risers in buildings.	s–15 yrs.	One small repair after 15 yrs.	15 yrs. Still good
13. Lockhart Apts. 201 Millvale Ave.	6	1906	No repairs to hot or cold water.	11 yrs. Still good	11 yrs. Still good	11 yrs. Still good
14. Bovard Apts. 200 Millvale Ave.	6	1902	Practically no repairs to hot water, but beginning to rust out.	s–16 yrs.	15 yrs. Still good	15 yrs. Still good
15. Albion Apts. 205 Millvale Ave.	6	1902	Hot water mains replaced in 1913.	11 yrs.	11 yrs. Still good	11 yrs. Srill good
16. Clarendon Apts. 211 Millvale Ave.	6	1902	Some of hot water mains replaced 1914-15.	s–13 yrs.	15 yrs. Still good	15 yrs. Still good
17-18. McLean Apts. 256 Mathilda (2 units).	6	1899	Most of hot water mains replaced 1915 with steel; the latter already pitted through in four places and tied up with rags.	s–17 yrs.	18 yrs. Still good	18 yrs. Still good
19. Colonial Apts. Hays St., Wilkinsburg.	47	1899	Hot water mains required minor repairs since 1912. Now needs replacing.	17 yrs.	18 yrs. Still good	18 yrs. Still good
20-21. Colonial Annex No. 1 and 2. (2). Franklin Street.	24	1902	Hot water mains still in fair condition. Very few repairs.	s–18 yrs.	15 yrs. Still good	15 yrs. Still good
22-25. 503, 511, 515 and 539 Rosedale St. (4 units.) Wilkinsburg.	6	1901	Wrought iron mains and lead risers for hot water; both replaced in 1915. 160 lbs. water pressure, Wilkinsburg water, same as Pittsburgh.	14 yrs.	Lead 14 yrs. (Replaced)	16 yrs. Still good
26. 519 Rosedale St.	6	1901	Instantaneous hot water heater. Both iron mains and lead risers still in fair condition.	s–18 yrs.	Lead s–18 yrs.	16 yrs. Still good
27-32. 523, 527, 531, 535, 543 and 547 Rosedale St. (6).	6	1901	Hot water lines have had some repairs, but are still in fair condition. Iron and lead plugging, and have had to be cleaned out.	s–16 yrs.	Lead 16 yrs.	16 yrs. Still good
33. Seeley Block Penn and Beatty.	6	1897	Pipe around hot water heater gradually replaced since 1912.	s–17 yrs.	20 yrs. Still good	20 yrs. Still good

WROUGHT IRON INSTALLATIONS (Continued)

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
34-36. Norfolk Apts. Delaware Apts. Howard Apts. (3) Cor. Bryant and Hiland.	6	1898	Hot water basement mains largely replaced 1912 to 1917. Risers now leaking.	s–17 yrs.	19 yrs.	19 yrs. Still good
37. Verner Apts. 3801 California.	6	1900	Basement mains replaced in 1914.	14 yrs.	17 yrs. Still good	17 yrs. Still good
38. Hiawatha Apts. 3803 Hiawatha St.	6	1906	Still good. No trouble.	11 yrs. Still good	11 yrs. Still good	11 yrs. Still good
39. Minnehaha Apts. 3805 Hiawatha St.	6	1906	Still good. No trouble. Showing slight corrosion at joints in basement.	11 yrs. Still good	11 yrs. Still godo	11 yrs. Still good
40. Tacoma Apts. 3805 California Avenue.	6	1911	Still good; no trouble.	Still good	6 yrs. Still good	6 yrs. Still good
41. Denslow Apts. 3624 California Avenue.	12	1904	Equipped with wrought iton pipe of doubtful quality, being high in manganese. Needs replacement in basement.	13 yrs.	13 yrs. Still good	13 yrs. Still good
42. Lafayette and Cambridge Apts. McKee Place.	12	1902	Most of hot water mains in basement replaced 1917.	14 yrs.	14 yrs. Still good	14 yrs. Still good
43. Yellow Brick Apt. McKee Place.	12	1902	Repairs started in 1915. Entire basement hot water piping now needs replacement.	14 yrs.	14 yrs. Still good	14 yrs. Still good
44. Yellow Brick Apts. No. 2. McKee Place.	6	1902	Some of hot water mains replaced, all now need replacement.	14 yrs.	14 yrs. Still good	14 yrs. Still good
45. Hanover Apts. McKee Place.	12	1903	Hot water mains in basement replaced in 1915; stopping up and corroding at joints.	12 yrs.	13 yrs. Still good	13 yrs. Still good
46. Cheswick Apts. McKee Place.	6	1903	Small repairs made 2 yrs. ago near boiler in basement. Entire hot water piping in basement will need replacement in a year or two.	s–14 yrs.	14 yrs. Still good	14 yrs. Still good
47. Olympia Apts. McKee Place.	12	1903	Some repairs made 1915 to hot water mains in basement. Same will have to be replaced soon.	14 yrs.	14 yrs. Still good	14 yrs. Still good
48. Dundee Apts. McKee Place.	12	1902	Hot water pipe in basement replaced in 1915.	13 yrs.	15 yrs. Still good	15 yrs. Still good
49. Wabash Apts. McKee Place.	12	1902	Hot water mains replaced 1915-1916.	13 yrs.	15 yrs. Still good	15 yrs. Still good
50. Jarvis Apts. McKee Place.	12	1902	Hot water mains replaced 1914, account plugging and rusting.	12 yrs.	15 yrs. Still good	15 yrs. Still good
51. Lancaster Apts. McKee Place.	12	1903	Hot water mains in basement replaced 1915, account leaking and plugging.	12 yrs.	14 yrs. Still good	14 yrs. Still good
52. Saybrook Apts. Craft Ave.	95	1901	One length of pipe replaced 1912 with steel: the latter is rusted through and leaking after 4½ years. All hot water lines in basement now needing replacement within a few years. Lower ends of risers also corroded.	s–17 yrs.	16 yrs. lower ends corroded	16 yrs. Still good

WROUGHT IRON INSTALLATIONS (Continued)

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
53. Amelda Apts. Melwood and Baum.	6	1907	Entire hot water system now being replaced (1917). Risers plugged up, being too small. (Near pumping station.)	10 yrs.	10 yrs.	10 yrs. Still good
54. Margarita Apts. Melwood Ave	6	1907	Entire hot water system replaced 1916. (Near pumping station.)	9 yrs.	9 yrs.	10 yrs. Still good
55. Oakland Apts. Halket and Forbes.	12	1902	Hot water mains need replacement.	15 yrs.	15 yrs. Still good	15 yrs. Still good
56-58. Shadyside Apt. 5121-25 Centre Ave. (3 bldgs.)	6	1902	Instantaneous hot water heater (3). Basement mains replaced 1915.	13 yrs.		
59-61. Shadyside Apt. 5115-19 Centre Ave. (3 bldgs.)	6	1902	Hot water mains replaced in 1915.	13 yrs.	Brass Still good	Good after 15 yrs.
62. Geneva Apts.	6	1902	Hot water mains replaced in basement in 1915.	13 yrs.	Lead	Lead
63. Virginia Apts.	6	1902				
64. Lincoln Apts.	6	1902				
65. Columbia Apts.	6	1902				
66. Emerson Apts. (All Mathilda St.)	6	1902				
67. Burlington Apts. McKee Place.	12	1903	Hot water mains rusted out and need replacement.	14 yrs.	14 yrs. Still good	14 yrs. Still good

BRASS PIPE INSTALLATIONS

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
1. Iroquois Apts. 3600 Forbes St.	74	1903	Hot water lines badly pitted throughout, including mains, risers and returns.	Pitted	Pitted	Still Good
2. Elsinore Apts. Craft Ave.	6	1902	Hot water mains badly pitted throughout.	Pitted	Pitted	Still good
3. 306 Craft Ave.	6	1902	Hot water mains badly pitted throughout.	Pitted	?	Still good
4. Kennett Apts. Kennett Square	6	1902	Hot water pipe badly pitted in basement.	Pitted	?	Still Good
5. Craft Apts. Elsinore Square	6	1902	Hot water pipe badly pitted in basement.	Pitted	?	Still good
6. Colonial Apts. Craft Ave.	6	1902	Hot water pipe badly pitted in basement.	Pitted	?	Still good
7. D'Arlington Apts. Cor. Bayard and Neville Sts.	24	1909	Hot water lines show much corrosion at joints; also pitting.	Pitted	?	Still good
8. Holland Apts. Louisa and McKee Place	12	1904	Hot water mains badly pitted.	Pitted	?	Still good
9. Wiltshire Apts. 219 Millvale Ave.	6	1900	Hot water mains in basement somewhat pitted.	Pitted	?	Still good
10. Apartments 5810 Kentucky Ave.	6	1910	Slight pitting of hot water main.	Slightly Pitted	?	Still good

BRASS PIPE INSTALLATIONS (Continued)

Name and Location	No. of Apts.	Year Erected	Remarks	Hot Water		Cold Water Lines
				Mains	Risers	
11. Kretzschmar Apt. 912 Maryland Ave.	6	1906	Both hot and cold water lines pitted throughout building. Pitting started when building was 3 years old.	Pitted	Pitted	Pitted
12-14. Pen wood Apts. 5736-48 Kentucky Ave. (3 units)	6	1910	Pipe slightly pitted in basement.	Slightly Pitted	?	Still good
15. Seneca Apts. 2041 Forbes St.	12	1906	Steel pipe originally installed, rusted out and replaced with brass in 1915.	Pitted	?	Still good
16-17. Howe and Kent Apts. Howe and Maryland	6	1907	Hot water mains show some pitting.	Pitted	?	Still good
18-19. Bellefonte Apts, Elm and Bellefonte (2 units).	6	1900	Instantaneous heater; pipe somewhat pitted.	Pitted	?	Still good
20. Walnut Apts. Cor. S. Negley and Elwood.		1911	Instantaneous heater; pipe in good condition.	Good	Good	Good
21. Fairview Apts.	6	1906	Hot water pipes only slightly pitted.	Slightly Pitted	?	Good
22. Maryland Apts. 632-34 Maryland	3	1906	Hot water pipes only slightly pitted.			
23-26. Wallace Apts. 512-26 Wallace St. (4 units.)	6	1906	Temperature of hot water is kept rather low. Pipe in good condition.	Good	Good	Good
27. Lorain Hotel Highland Avenue	Abt. 6	1902	Hot water mains all pitted.	Pitted	?	Iron, good
28. Montana Apts. Penn Ave.	8	1899	Hot water mains all pitted.	Pitted	?	Iron, good
29. Idaho Apts. Penn Ave.	8	1899	Hot water mains all pitted.	Pitted	?	Iron, good
30. Hugus Apts. 5500 Penn Ave.	9	1909	Hot water mains pitted.	Pitted	?	Good
31. Rosemont Apts. Penn and Fairmont.	4	1909	Hot water mains pitted.	Pitted	?	Good
32. Elberon Apts. Friendship and Winebiddle.	6	1901	Hot water lines all pitted.	Pitted	?	Good
33. Wellington Apts. Sycamore St. and Maple Terrace	18	1906	Hot water mains all pitted.	Pitted	?	Good
34. Horst Apts. California Ave.	6	1900	Hot water mains pitted.	Pitted	?	Good

MANGANESE TEST

Place a small chip about the size of a large pinhead, or filings to equal this quantity, in a small, clean test tube. Add twenty drops of chemically pure nitric acid, specific gravity 1.2, and heat with a match until the metal is completely dissolved. Let the solution cool until the tube can be held in the hand without discomfort, and add as much sodium bismuthate as will lie on the point of a small penknife blade, or as much more as may be required to produce a small amount of brown residue. Bubbles of oxygen gas will be given off by the solution

when the bismuthate is added, after which the development of a pink or red color may appear in the solution, indicating the presence of manganese which shows that the material is steel. If no reddish tint appears, or only a very slight pinkish discoloration is visible, the material is iron.

If wrought iron contains more than a trace of manganese, which occasionally happens, this test is misleading. A fracture test or chemical analysis is, therefore, preferable whenever possible. It should also be noted that "Ingot Iron" and other soft steels of very high purity, contain only a trace of manganese, but so little pipe is as yet made from these materials that the possibility may be practically ignored.

ANALYSIS OF WATER

The Pittsburgh water supply is obtained by slow filtration of river water, coupled with very slight additions of chlorine to destroy bacteria. The water is moderately hard and of good quality for domestic consumption.

The records obtained of the comparative life of wrought iron, steel and brass pipe in Pittsburgh apartment buildings, are applicable to similar service in most of the large cities of this country. The water supplies of such cities are in general obtained from lakes or rivers, and do not differ sufficiently from the Pittsburgh supply in contained salts to be materially different in corrosive effect.

The only place where the use of the data may result in error is in certain smaller cities where the water supply is obtained from artesian wells or similar sources. These may differ sufficiently in composition and hardness from the Pittsburgh supply, to make comparisons somewhat misleading. However, it may be said in general that if the salt content of domestic water supply is not sufficient to affect its potable quality, the *difference in the corrosive effects of the various waters is quantitative only, and only in exceptional cases will there be a disturbance of the relative effect upon wrought iron, steel and brass. The comparative data secured in Pittsburgh, therefore, has almost universal application.* Following is a representative analysis of Pittsburgh water compared with analysis from a few other large cities:

Analysis of Domestic Water Supply in Large Cities.

City	Source of Supply and Treatment	PARTS PER MILLION						
		Sodium and Potassium	Calcium	Magnesium	Silica	Sulphate	Chlorine	Carbonate
Pittsburgh	Allegheny River. Settling, sand filter, chlorine sterilization.	6.8	28.6	7.3	2.6	93.8	21.0	.....
Cincinnati	Ohio River. Settling, coagulation, sand filter, chlorine sterilization.	.....	30.5	4.8	.....	47.3	17.0	26.9
Philadelphia Schuylkill Delaware.	River. Sand filter.	(Analysis not complete as to bases)				45.6 13.2	5.3 5.1	.....
Washington, D. C.	Potomac River. Sand filter, settling.	2.9	43.6	6.8	8.8	11.4	3.9	114.8
Minneapolis	Missippi River. Settling, coagulation, sand filter, chlorine sterilization.	7.3	39.9	12.7	8.9	26.7	2.2	161.0
St. Louis.	Missippi River. Settling, coagulation, sand filter, chlorine sterilization.	28.8	21.0	11.7	9.6	84.2	13.4	55.0
New Orleans.	Missippi River. Settling, coagulation, sand filter, chlorine sterilization.	13.0	15.0	3.0	10.0	31.5	9.6	.....
Atlanta, Ga.	Chattahoochee River. Coagulation, mechanical filter.	2.6	Trace	Trace	2.0	2.6	.....	1.6
New York Catskill. Croton.	Impounding of river water in reservoirs.	0.8 2.0	5.2 9.6	0.8 3.4	1.0 9.0	3.2 8.0	1.2 3.0	17.4 38.4
Chicago.	Lake Michigan. Chlorine sterilization.	1.1	29.2	11.8	3.9	10.0	6.3	65.4
Los Angeles.	Aqueduct. Los Angeles River. Settling.	52.0 39.3	45.0 68.6	16.0 23.8	.....	109.0 98.9	30.0 29.0	15.6 22.6
Indianapolis, Ind.	River. Coagulation, sand filter, chlorine sterilization.	13.0	72.0	27.0	.....	58.0	20.0	136.5
Houston, Texas.	Artesian Wells.	71.4	29.5	3.5	.....	13.6	49.4	147.9
Memphis, Tenn.	Artesian Wells.	35.6	13.8	13.0	.....	4.2	53.8	53.0
Milwaukee, Wis.	Lake Michigan. Not filtered. Chlorine sterilization	4.9	39.2	9.8	12.5	8.2	3.8	130.0
Ocean Water		**11100.0**	**420.0**	**1300.0**	.....	**2700.0**	**19350.0**	**70.0**

NOTE: It will be observed that all of the analyses given show only negligible amounts of impurities which have any effect on corrosion. This is being illustrated by comparison with the analysis of ocean water.

THE CORROSION OF HOT WATER PIPING IN BATH HOUSES

A few comments on the interpretation of Mr. Ira H. Woolson's Report, published in the Engineering News, December 3rd, 1910, page 630.

The Byers Company has recently devoted much time and effort to the collection of exact data on the life given by iron and steel pipe in actual service. Besides this Bulletin, No. 30, during the past six years the following publications, containing a large number of service records, have been issued:

Bulletin No. 26-A—"What is Wrought Iron?"

Bulletin No. 27—"The Experience of Practical Men," containing the testimony of practical men in every part of the country, as to the life of iron or steel pipe for a wide variety of uses.

Bulletin No. 32—"The Relative Corrosion of Wrought Iron, Cast Iron and Steel Pipe in House Drainage Systems." Data obtained through investigations conducted in New York by Dr. Wm. Paul Gerhard, C. E., Consulting Sanitary Engineer, and in Chicago by Thomas J. Claffy, Asst. Chief Sanitary Inspector, City of Chicago.

Bulletin No. 34—"Corrosion of Pipe in Refrigerating Systems" containing service records on Ammonia condensers.

Book: "On the Trail of Byers Pipe,"—40 pages of illustrations of old buildings from 25 to 45 years old, describing the service given by the pipe in each.

Against this exact data, manufacturers of steel pipe appear to rest their case on the one single piece of evidence that could possibly be interpreted in favor of the contention that steel pipe lasts as long as iron. This refers to Professor Ira H. Woolson's report on the "Corrosion of Hot Water Pipes in New York Bath Houses." This report has been published and republished, one edition following another, for the last ten years, and has been quoted by exponents of steel pipe on every possible occasion, remaining throughout all these years the mainstay of their propaganda. One is therefore tempted to ask this question: If steel pipe really lasts as long as wrought iron pipe, why not produce some definite evidence of life in actual service of pipe tested to destruction? This question is not answered by the report of Professor Woolson who beyond question, never intended his report to be used for this purpose, for in the very beginning he clearly states:

> "This paper represents the *Progress* of the work up to May, 1910, when I severed my connection with that institution (Columbia University). The original plan was to *collect further evidence* * * * but as that is now impossible * * *."

And further:

> "I visited all the public bath houses * * * collecting all the samples of corroded pipe I could secure. In some places it was difficult to get satisfactory samples because the old piping was sold for junk as rapidly as possible."

It is difficult, therefore, to understand how anyone could have utilized Mr. Woolson's Report for the purpose of showing that steel pipe will last as long as iron pipe when tested to destruction, for although all the pipe was actually removed because it had rusted out, nowhere in Mr. Woolson's Report is any mention made of the *length of time each sample had been in service.*

This vital point of time was not touched on at all by Mr. Woolson, no doubt due to the fact that it was impossible for him to obtain this information about samples, collected largely from the scrap pile, from a number of buildings which were not of the same age. The 23d Street bath house, at the time of the investigation, was about one year old, the 76th Street bath three or four years, the 11th Street and Allen Street baths four years, the 109th Street bath four or five years, the 41st Street bath five years and the Rivington Street bath eight years.

In lieu of a comparison of life, Mr. Woolson thought that a comparison of the iron and steel samples might reveal a difference in their condition, but any such expectation naturally was foredoomed to disappointment, as one piece of pipe which has failed in service, from a practical standpoint, can be no worse nor better than another pipe which has also failed in service due to the same cause—corrosion. Unless a correct answer can be given to the question, "How long was each sample in service?" the other comparison is valueless.

Bulletin No. 34—The Life of Pipe in Refrigeration Service. Containing service records on ammonia condensers.

1. "Steam Drips" carrying hot water condensed from the steam lines which is returned to the boiler. (This is usually black pipe.)

2. Boiler feed lines, also hot water (usually black pipe.)

3. Hot water supply line between the heater and the shower lines (galvanized.)

4. The "shower lines" proper, which are the overhead lines in the bath rooms, to which the shower heads are attached (galvanized.)

5. The hot water return lines from the shower lines (galvanized.)

The samples collected were both black and galvanized, varying in size from ¾ to 4″, showing that they must have been installed under *greatly varying conditions of service.* For a boiler feed line invariably has a life several times shorter than a hot water supply line, and a drip or return line will usually last much longer than the supply line. This is another important point on which Mr. Woolson was prevented from throwing any light, owing to collecting the samples so largely from the junk pile. But the first and last question that must be asked of those who are quoting Mr. Woolson is: Where is the time record of service?

In the extensive remodeling done to the various baths in 1911, (after Mr. Woolson's investigation), *genuine* wrought iron was specified for all hot water lines in the plumbing system of the baths and special care was taken to prevent the substitution of steel pipe. It is of interest to note that this piping has so far required very few repairs. In the Rivington Street bath, erected 1914, Byers pipe apparently was installed throughout, and up to, March, 1917, (the date of our last visit to this bath) no repairs had been required on account of rusting.